

RECORDING AND PLAYBACK CONTROL SYSTEMFIELD OF THE INVENTION

1 This invention relates to systems for recording and
2 playing back audio information on optical recording media. In
3 particular, it relates to such systems that compensate for the
4 differences between the characteristics of the recording and
5 playback sites.

BACKGROUND OF THE INVENTION

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7 The present invention is concerned with apparatus and
8 methods for playing back recorded material from media, particu-
9 larly, but not strictly limited to high density optical recording
10 media such as DVD discs containing acoustic data, e.g., music.
11 For purposes of this disclosure, the term "music" is to be under-
12 stood throughout to include the possibility of video. A serious
13 limitation of the present systems is that they record music in a
14 studio or a concert hall and leave it to the listener/viewer
15 (herein termed the "listener") to adjust the playback apparatus
16 to attempt to reproduce the artist's intended sound in a differ-
17 ent playback site, i.e., his home, or car. However, because the
18 recording and playback sites almost always have different
19 acoustic characteristics, it is not feasible for the listener
20 satisfactorily to manage the adjustment of the playback equip-
21 ment.
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1 SUMMARY OF THE INVENTION

2 The present invention provides a system for recording
3 and reading audio visual control data (herein termed "acoustic
4 control data"), together with the musical program data, and play-
5 ing back the program data in accordance with the acoustical con-
6 trol data to optimize performance of audio reproduction and re-
7 create the original acoustic environment. Basically, it provides
8 a system for incorporating the acoustic control data into the
9 information stored on the media and, during playback, provides
10 components responsive to the control data during the playing back
11 of the musical program. The acoustic control data includes
12 several parameters and may be used to adjust the operation of the
13 playback system as accurately and as often as desired, down to
14 millisecond intervals.

15 The system of the invention comprises a recording
16 apparatus, a playback apparatus and a high density digital
17 recording media, such as DVD. The recording apparatus comprises
18 in addition to the standard equipment, a precision microphone, a
19 controller, a test signal generator and a data multiplexer to
20 produce recording media having both the acoustic control infor-
21 mation and the audio data.

22 The playback system comprises a demultiplexer, a cus-
23 tomer input interface giving the user some ability to override
24 the otherwise automatic parameter adjustments, optionally a meta-
25 data display system that takes information about the physical
26 arrangement of instruments in the recording studio and makes that
27 information visually available to the listener, and a register

1 that identifies the characteristics of the playback apparatus.
2 The playback apparatus further includes data processing compo-
3 nents for processing the acoustic program data, these components
4 being dynamically controlled using the acoustic control data.

5 An open and closed loop control scheme is also pro-
6 vided. In the open loop scheme, the acoustic characteristics of
7 local playback site are provided to the playback apparatus by the
8 listener at the playback apparatus.

9 In the closed loop control scheme, the acoustic param-
10 eters of the playback site are automatically determined, by gen-
11 erating acoustical test signals and sensing the responses. In
12 either case, the characteristics of the recording and playback
13 sites are compared and used to control the operation of the play-
14 back components.

15 The playback apparatus may also include a noise can-
16 cellation circuit which receives special information of the
17 acoustic program data from the recording site.

18 19 **BRIEF DESCRIPTION OF THE DRAWINGS**

20 Figure 1 shows a block diagram for the recording appar-
21 atus;

22 Figure 2 shows a typical sector on a recording media in
23 accordance with the invention;

24 Figure 3 shows a block diagram of the playback appar-
25 atus;

26 Figure 4 shows details of the delay circuit;

1 Figure 5 shows a block diagram for the closed loop
2 control configuration; and

3 Figure 6 shows a block diagram for a noise cancellation
4 circuit in accordance with the present invention.

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6 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

7 The invention shall now be described for a particular
8 preferred embodiment in conjunction with the drawings. This pre-
9 ferred embodiment of the present system concerns the generation
10 and replaying of audio data recorded on a pure audio DVD (digital
11 versatile disk). The DVD is an optical recording disc medium
12 having very high data density and MPEG compression of the audio
13 data. The system consists, in addition to the DVD, of a record-
14 ing apparatus, which herein shall refer to collectively all the
15 equipment involved in generating a DVD media having data repre-
16 sentative of a live performance of music or other similar per-
17 forming activity, and a playback apparatus in which the data from
18 the DVD is reproduced for the listening pleasure of a customer.

19 Referring to Figure 1, the recording apparatus 10 is
20 disposed at a recording site or venue. It includes a plurality
21 of primary microphones 12 used for picking up sounds generated
22 during the performing activity. The signals generated by these
23 microphones 12 are fed to a multichannel recorder 14. The
24 signals may be stored in the recorder 14, for later processing or
25 may be fed immediately to a mixer 16. The mixer 16 combines
26 these signals into a multi-channel and stereo stream of audio

1 data, which for the sake of simplicity, shall be referred to as
2 the program data.

3 An important feature of the present invention is that
4 prior to the performance being recorded, a data generator 18
5 determines the acoustic conditions of the recording venue and/or
6 control room for the performance and stores the same in a memory
7 20. In order to determine these conditions, the generator 18
8 activates a test signal generator 22 which in response generates
9 a predetermined test signal to an auxiliary speaker 24. A preci-
10 sion microphone 17 senses the response at the recording locale
11 to the test signal and sends the same to generator 18 and stores
12 it in memory 20. The recording locale (or venue) is the actual
13 zone where the performance takes place. In addition, the data
14 generator 18 also receives mixing information from the mixer 16
15 and stores the same in memory 20 as well. Additionally, the
16 producer of the performance may enter specific data regarding the
17 reproduction of the performance to memory 20 via a keyboard 26.
18 All of this information shall be referred to collectively as
19 acoustical control data.

20 The acoustical control data stored in memory 20 is
21 interleaved with the audio information on the DVD as described
22 more fully below and is used during the playing of the DVD,
23 either to recreate the conditions under which the recording was
24 made and/or other conditions selected by the producer. More
25 particularly, the memory 20 contains information descriptive of
26 the acoustic characteristic of the room where the recording

1 occurs. Of course these characteristics are dependent on the
2 size of the room, the composition of the wall coverings, the
3 height, etc, all of which affect how the sounds are recorded.
4 These characteristics in turn affect certain acoustical
5 properties such as delay, reverberation, and so on, and are
6 determined by data generator 18 from the response to the test
7 signal from generator 22.

8 In addition, the manner in which the sounds from the
9 different microphones 12 are mixed, i.e. the various proportions
10 or ratios are important when the performance is replayed,
11 especially in a multichannel system since, for most accurate
12 reproduction, the sounds should be replayed by speakers in
13 proportions corresponding to these mixing ratios as described
14 below. Accordingly, this information is also recorded in memory
15 20.

16 Finally, the producer may desire to change some of
17 these characteristics. This is especially desirable if when
18 multichannel signals are folded down to generate two-channel
19 stereo sounds. The producer has the ability to define the fold
20 down characteristics using keyboard 26.

21 The producer may optionally also provide to the data
22 generator various other parameters. Alternatively, this infor-
23 mation may be provided automatically from the mixer 16, the re-
24 cording equipment or another microphone. Some of these param-
25 eters are:

26 instrumental placement;

1 instrument separation partition placement;
2 peak or RMS limiting in the mixer 16;
3 equalization, compression and other similar recording
4 information;
5 studio and/or control room dynamic data such as reverb
6 time, delay time, standing waves, ambient noise;
7 room frequency response, room dynamic information; etc.

8 The acoustical visual control data, or AVCD, is fed to
9 multiplexer 28 which combines the program data with this AVCD and
10 feeds the same to a formatter 30. Formatter 30 partitions the
11 combined data and, if necessary, adds additional data including
12 for example parity codes, error correction codes, etc., in
13 conformance with a particular DVD standard used. The resulting
14 data is recorded on a DVD by a recording device 32.

15 A typical data sector 40 shown in Figure 2 and consists
16 of a header portion 42 and a data portion 44. In a typical DVD
17 scheme, the data portion 44, which normally is reserved to the
18 actual program data is 2048 bytes and the header portion 42,
19 which carries other types of signals and contains 156 bytes. In
20 the present invention, a small section 46 is carved out, prefer-
21 ably of the data portion 44, as shown, and dedicated for the AVCD
22 signals. In Figure 2, section 46 is shown at the beginning of
23 the data portion 44, however it may be disposed at other loca-
24 tions as well.

25 While in Figure 2, AVCD is shown as being provided in a
26 sector 40, it should be understood that this data need not be

1 repeated in every sector. Instead, the AVCD may be provided in
2 every sector on the DVD or, in an ultimate case, once for each
3 DVD.

4 The other portion of the subject system is the playback
5 apparatus. As shown in Figure 3, this playback apparatus 50 in-
6 cludes a demultiplexer 52, an AVCD buffer 54 for the AVCD signal
7 and a buffer 56 for the program data. The demultiplexer 52
8 separates the AVCD and the program data for the respective
9 buffers 54, 56 from the incoming data as it is read off the DVD.
10 It also reads the header information and performs other control
11 functions, such as error correction, which do not form a part of
12 this invention. A DVD player which shows details of such a
13 demultiplexer is disclosed in U.S. Patent No. 5,463,565, incor-
14 porated herein by reference.

15 Preferably player 50 is a multichannel audio DVD player
16 capable of generating six channels. (Such players are commonly
17 referred to as generating 5.1 channels, the last channel being
18 dedicated to a low frequency subwoofer.)

19 The program data from buffer 56 is fed via six lines
20 L1-L6, to six processing channels. Typical processing circuits
21 are shown in Figure 3 for one channel, it being understood that
22 the elements for the other channels are substantially identical.

23 The program on L1 is fed first to a gain/phase circuit
24 58 for amplification, gain adjustment and phase correction in
25 accordance with certain control signals as described below.

26 The adjusted signals are sent to a delay/reverberation

1 circuit 60 where the delay of the signals for appropriate
2 reverberation are adjusted. The signals are next sent to an
3 equalizer 62. After equalization, the signals are sent to a
4 multiplexer 64.

5 The operation of the multiplexer 64 is dependent on the
6 number and arrangement of speakers that the costumer wants to
7 use. For a full 5.1 channel surround sound, the multiplexer
8 sends the signals to an appropriate speaker 66, it being under-
9 stood that similar speakers are provided for each of the other
10 channels.

11 To achieve two channel 'stereo sound', the multiplexer
12 64 first sends the sounds for channel 1 to a mixer 68 on line m1.
13 This mixer 68 also receives signals on lines m2, m3 for signals
14 from other channels. The signals from these channels are mixed
15 at certain ratios described more fully below, to generate a
16 'left' signal for a speaker 70. Similarly signals from lines m3,
17 m4, m5 generated by other channels (not shown) are fed to a
18 second mixer 68' where they are combined to generate a so-called
19 'right' signal for a speaker 70'. Thus, in effect, the two
20 mixers 68, 68' fold the signals from six channels into a standard
21 two-channel stereo signals.

22 In addition, the playback apparatus 50 further includes
23 a customer input interface 80 and a register 82. The customer
24 input interface 80 is used by the customer to input his prefer-
25 ences, and, if so desired, to override the AVCD as described more
26 fully below. The register 82 is used by the manufacturer to

1 store certain device specific information, such as whether the
2 player is an automobile player, a home player, a personal or
3 portable player, a studio player, and so on.

4 ~~The goal of any sound player is to reproduce a recorded~~
5 ~~performance as accurately as possible by recreating the condi-~~
6 ~~tions under which it was recorded.~~ ^{The} Of course, the acoustic char-
7 acteristics of the playback site play an important role in the
8 accuracy of the reproduction. These characteristics include the
9 physical dimensions of the room where the playback apparatus is
10 to be used, including characteristics of the walls, the location
11 of the speakers, etc. For best reproduction quality, the play-
12 back apparatus 50 should have information descriptive of all
13 these characteristics.

14 Two configurations are envisioned for providing these
15 local characteristics to the playback apparatus 50. In one con-
16 figuration, an open loop control is used. In this configuration,
17 the customer provides the descriptive information to the playback
18 apparatus 50. For example, in response to prompts, the customer
19 may enter the size of the room, the location of the speakers,
20 etc. This information is then stored in memory 83. In addition,
21 related acoustic parameters, are also determined and stored in
22 memory 83.

23 The information from memory 83 and register 82 is used
24 by each of the elements 58, 60, 62, 64 in conjunction with the
25 ACD information from buffer 54 to perform their respective func-
26 tions. This feature of the invention is best explained in

1 conjunction with a specific element. Figure 4 shows details of
2 the delay circuit 60. The delay circuit 60 includes a program-
3 mable delay line 91 and a control block 92. The control block
4 receives a reference delay parameter which is one of the param-
5 eters of the AVCD and is determined at the recording site 10.
6 The control block also receives an input from register 82, or
7 memory 83.

8 Control block 92 may be for example a look-up table
9 which uses the information received to generate an appropriate
10 delay for the signals of channel 1, by comparing for example the
11 delay characteristic of the room with the optimal delay indicated
12 by the reference delay parameter. This delay control signal is
13 then fed to programmable delay line 91. For example, the orig-
14 inal performance may have been recorded in a concert hall having
15 a delay time of 2 seconds. On the other hand the customer may be
16 keeping his player in relatively small room with a delay of 0.5
17 seconds. Therefore for optimum playing a delay of 1.5 sec is
18 required. This delay is developed by delay line 91 as defined by
19 the control block 92.

20 Of course, the customer may desire to have the sounds
21 played with different characteristics. He may chose these char-
22 acteristics using the customer interface 80. When the customer
23 makes his choice, rather than having the system generate the
24 delay automatically, the customer choice is fed to the controller
25 block 92 from memory 80 and is used to override any previous
26 decisions.

1 Thus the operation of each of the elements 58, 60, 62,
2 64 is adjusted using information from the AVCD, the register 82,
3 memory 83 and the customer input interface 80.

4 Of particular importance are the mixing ratios used by
5 mixer 68. As discussed above, these ratios can be set using in-
6 formation from the ACD which is derived from information on how
7 the mixer 16 is set, and, optionally, the ratios set by the pro-
8 ducer using keyboard 26.

9 In the second configuration of the invention a closed
10 loop control system is used. In this configuration, a control
11 circuit 100 is provided which includes (Figure 5) a microphone
12 102, an amplifier 104, a processor 106, and test generator 108.
13 The test generator is used to generate on command a test signal.
14 For example, the test generator may be used to generate pink
15 noise, or a particular test sound defined by the AVCD. This test
16 signal is transmitted to the speakers of the player 50. The test
17 may be identical to the test signal from generator 22.

18 Preferably the microphone 102 is located, at least tempor-
19 arily, at a central location within the room wherever the cus-
20 tomer prefers to listen to the player. The microphone 102 is
21 connected via the amplifier 104 to the processor 106 either by
22 direct wiring or by an indirect coupling such as RF, IR, or other
23 similar means.

24 In any event, the processor 106 routes the test signals
25 from generator 108 to each of the speakers 66 serially and/or
26 simultaneously to allow the processor to analyze the acoustic

1 characteristics of the customer's listening room, including its
2 size, wall covering, speaker locations, and so on. Thus, instead
3 of having the customer enter information and calculating these
4 characteristics, the characteristics are obtained directly.
5 These characteristics may have to be adjusted to compensate for
6 changes in the room.

7 After the characteristics are obtained as described,
8 they are stored in a memory 110. The information from this mem-
9 ory is then used in the same manner as the information from mem-
10 ory 83. Register 82 is still used to store player specific
11 information.

12 The AVCD may be used for other important information as
13 well. For instance, many high quality players, especially
14 players designed to be used in automobiles, may include a noise
15 cancellation circuit for canceling road noise. Noise cancella-
16 tion may be advantageously incorporated into the present system
17 as follows.

18 Referring to Figure 6, a noise cancellation circuit 140
19 includes a noise sensor 142, a noise correction generator 144 and
20 a mixer 146. Sensor 142 is used to sense ambient sounds and it
21 may be for example a local microphone. The noise signals thus
22 sensed are fed to the noise correction generator 144. The noise
23 correction signal also receives from the AVCD information des-
24 cribing the spectral content of the program data on the corres-
25 ponding channel, for example channel 1. The noise correction
26 generator 144 analyzes the sensed noise signals and generates

1 noise compensation signals. In this manner, the noise correction
2 generator 144 does not have to perform its own analysis to
3 differentiate between the desirable sound signals and the un-
4 desirable noise signals. These compensation signals are added to
5 the program signals by mixer 146. Mixer 146 in turn mixes the
6 channel 1 signals and the noise correction signals to thereby
7 compensate for noise.

8 As previously mentioned, the AVCD may include metadata
9 descriptive of the locations of the instruments, vocalists and/or
10 recording microphones. This information is captured and dis-
11 played by a display 90 at the playback apparatus to give the cus-
12 tomer a more accurate information about how the performance was
13 recorded.

14 Although the invention has been described in terms of
15 specific embodiments, it is intended that the patent cover equiv-
16 alent substitutions for any of the elements of these embodiments,
17 and that the protection afforded by this patent be determined by
18 the legitimate scope of the following claims.